4350 Load User's Manual

Part No. 09-0315

REVISION G

June 27, 2014

Document History

Rev X1	**Preliminary**	**6/13/2011**	**C. A. R.**
Rev X2	**Change resistance accuracy**	**10/05/2011**	**C. A. R.**
Rev A	**ECO 16936**	**1/05/2012**	**C. A. R.**
Rev B	**ECO 16880**	**3/08/2012**	**B. L.**
Rev C	**ECO 17016**	**7/25/2012**	**B. L.**
Rev D	**ECO 17150**	**3/29/2013**	**T. F.**
Rev E	**ECO 17183**	**1/10/2014**	**S.M.**
Rev F	**ECO 17233**	**5/28/2014**	**T.F.**
Rev G	**ECO 17237**	**6/27/2014**	**T.F.**

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1. SAFETY

1.1 WARNING: LIVE CIRCUITS

NO INTERNAL ADJUSTMENT OR COMPONENT REPLACEMENT IS ALLOWED BY NON-NH RESEARCH QUALIFIED PERSONNEL. COMPLETE THE FOLLOWING BEFORE ACCESSING THE INSTRUMENT INTERNALS:

- **REMOVE ALL EXTERNAL VOLTAGE SOURCES**
- **DISCONNECT POWER CORD**
- **WAIT A MINIMUM OF 1 MINUTE TO DISCHARGE CIRCUITS**
- **VERIFY CIRCUITS ARE DISCHARGED**

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2. DESCRIPTION

The Model 4350s are a series of electronic programmable DC loads targeted to test voltage AC/DC and DC/DC converters. These loads use a state-of-the-art thermal management system to achieve a power density of 150W per slot, for a maximum of 2400W per 7¾ inch S4000 chassis. A unique multi-range design is used to cover test requirements from 2.3V to 500V in three ranges, and current from 660 milliamps to (30A 150W), (60A 300W) or (120A 600W) in three ranges. The power handling capability can be expanded through paralleling additional modules.

The 4350 Loads utilize a linear power design for fastest response time and quiet operation. Constant (current, power, resistance, and voltage) LED, MPPT and XY operating modes are provided. Macro and short circuit modes are also provided. An advanced Texas Instruments DSP processor is used to tightly synchronize paralleled modules, as well as provide programmable output waveforms with unprecedented accuracy compared with older, more limited analog designs.

A sampling Analog to Digital Converter is used for metering which allows the display of waveforms similar to a Digital Storage Oscilloscope.

2.1 Measurement Features

Voltage	30V, 120V, 600V Ranges, DC - 500khz, isolated, bipolar, AC or DC coupled
Current	Range same as set, DC - 100khz, bipolar
Peak to Peak Noise	0.25V, 2.5V, Peak to Peak, 10hz-20MHz
Sample rate	1MS/s
Record length	256k points
Trigger	System, DINs, Voltage, Pretrigger
Voltage and Current	Overshoot, Undershoot, AC RMS, AC+DC RMS, Pos Peak, Neg Peak, Peak to Peak, Rise Time, Fall Time, Settling Time, Hold Up Time
Other	Average and Peak Power, Resistance, Trigger In Time, DIN State and Time

2.2 Common Load Features

Voltage ranges	30V, 120V, 500V
Hardware Modes	CC, CR, CV, with 16 bit DACs, LED
Firmware Modes	CP, Auto, Slew, MPPT, XY, 1000 step Macro with mixed modes
Analog Control	Yes
Current Monitor	Yes
Parallel Loads	Yes, in hardware to 600W and/or software to 2400W
DINs	2 Isolated
DOUTs	2 Isolated and OVPS Relay
Protection	Over voltage, current, power, temperature, reverse voltage

2.3 150W Load Features

Current ranges	0.66A, 3A, 30A
Voltage @ Current	2.3V @ 30A
Resistance	0.15Ω - 35kΩ
Short-circuit Resistance	75mΩ @ 30A
Power	150W continuous, 200W peak

2.4 300W Load Features

Current ranges	0.66A, 6A, 60A
Voltage @ Current	2.3V @ 60A
Resistance	0.075Ω - 17kΩ
Short-circuit Resistance	38mΩ @ 60A
Power	300W continuous, 400W peak

2.5 600W Load Features

Current ranges	0.66A, 12A, 120A
Voltage @ Current	2.3V @ 120A
Resistance	0.038Ω - 8.7kΩ
Short-circuit Resistance	19mΩ @ 120A
Power	600W continuous, 800W peak

3. SPECIFICATIONS

Accuracies apply when settings and/or measurements are greater than 10% of the range. At less than 10% of range, error increases. The additional error is (((10% of range) - value) * range error * 10).

3.1 Configuration

One isolated DC electronic load on one PCA (printed circuit assembly) rated at 30A 150W. Loads may be built as masters (fully stuffed) or auxiliary (only the power portion is stuffed for lower cost).

16 PCA's may be loaded into a chassis.

One LAN interface communicates with 16 loads.

Control power is supplied by a common DC power supply in the chassis.

AC is supplied on the back plane for future sources.

3.2 Size

Load 7.9 inch high, 0.9 inch wide, 18 inch deep.

Chassis 8.75 inch high, 19 inch wide, 22 inch deep.

3.3 Weight

5 lbs.

3.4 Protection

Over-voltage and reverse-voltage protections are provided by the avalanche rated body diode in the power MOSFETs.

Over-temperature protection is provided by a thermal sensor.

Over-current and over-power protection are provided in hardware and limit to the maximum for that range.

3.5 Isolation

±1000VDC from AC power input to load or chassis ground.

±600VDC from load to chassis ground.

3.6 Self-test

Power-up self-test is implemented in firmware. This will report comprehensive error messages about the status of the input, output, control and protection mechanism.

3.7 Calibration

Closed cover, all adjustments are done in software and stored in an on-board FLASH.

Equipment Required:
Multimeter, Hewlett Packard Model 3458A or equivalent

Accurate current measurement device or NHR Calibrator

3.8 Performance Monitoring

Performance monitoring is performed continuously by the Load's controller. In case of measurement ambiguities IE, over/under range conditions, heat sink temperature limits reached, an appropriate error or warning is sent to the controlling device.

3.9 Environmental

Operating from 0 to 35°C at 150W continuous.

Noncondensing, humidity < 75% R.H.

Specifications apply at 25°C ±5°C after 10-minute warm-up

3.10 Control power

Operational from 90 to 264VAC, 47-63Hz. DC power supplies in the chassis provides power to the loads and fans.

3.11 Analog Input and Output

0 to 10V external Modulation Input signal is provided which drives 0 to 100% current for that range. Accuracy is ±15%, repeatability is ±1%.

0 to 10V external Current Monitor output signal is provided which is 0 to 100% current for that range. Accuracy is ±15%, repeatability is ±1%.

These signals are referenced to the load negative input.

3.12 Parallel Loads

One master may be hardware-paralleled with up to three auxiliaries for higher current and power. Calibration data is only stored on the master. Auxiliaries may not be changed without recalibration. Two hardware paralleled PCA's are rated at 60A 300W and four hardware paralleled PCA's are rated at 120A 600W.

Multiple loads can be software-paralleled to form a single load instrument. Four separate groups may be paralleled using separate command sync signals provided on the back plane. This will insure multiple loads execute commands simultaneously.

Only loads in 1 chassis may be software-paralleled.

3.13 Voltage Sense

The voltage sense is fully protected against reverse input and over voltage conditions up to the full isolation rating of ±600VDC from the load or chassis.

Dedicated peak detect hardware stores positive and negative peak values for a short time. These values are summed and presented to the ADC. The DSP finds the maximum values in the buffer. The results are calibrated and returned as High Frequency Peak to Peak voltage.

3.14 Processor

Texas Instruments DSP is used in the load for control. A Net Burner module is used the chassis for the LAN interface.

3.15 Current Noise

Set current over-shoot is less than 10% of set + 100ma with less than 1Vp-p ripple.

Current over-shoot due voltage ripple is (voltage ripple)/µSeconds.

3.16 Digital Input

2 logic level DIN’s are provided per load for general-purpose input. The state may be measured. Timing measurements may be made from System Trigger to DIN’s or any waveform measurement.

DIN’s are isolated from the load and chassis up to ±600VDC. DIN’s are isolated from DOUT’s up to ±120VDC.

3.17 Digital Output

2 individually isolated solid state relay DOUT’s are provided per load for general-purpose output. DOUT’s are rated for ±100VDC, 300mA.

DOUT’s are isolated from the load and chassis up to ±600VDC. DOUT’s are isolated from DIN’s up to ±120VDC.

An Over Voltage Power Supply DPST 5A relay is also provided.

3.18 4350 150W Programmable Features

<table>
<tr><td>Constant Current</td><td>Range

Accuracy
Resolution</td><td colspan="3">0 to 0.66A
0 to 3A
0 to 30A
0.06% of set + 0.06% of range
16 Bits</td></tr>
<tr><td>Constant Voltage</td><td>Range

Accuracy
Resolution</td><td colspan="3">0 to 30V
0 to 120V
0 to 500V
0.05% of set + 0.05% of range
16 Bits</td></tr>
<tr><td>Constant Power</td><td>Range

Accuracy
Resolution</td><td colspan="3">0 to Current range times Voltage range
200W or 40W max
0.5% of set + 0.5% of range
16 Bits</td></tr>
<tr><td>Constant Resistance</td><td>Range

Accuracy</td><td colspan="3">15% to 5000% of
Voltage range divided by Current range
2% of set*</td></tr>
<tr><td>Short Circuit 30A range</td><td>Current
Resistance</td><td colspan="3">30A < Isc < 45A
75mΩ max</td></tr>
<tr><td>Slew Rate</td><td>Range
Maximum</td><td>0.66A
0.066A/µS</td><td>3A
0.3A/µS</td><td>30A
6A/µS</td></tr>
<tr><td>Macro Mode</td><td>Settings
Total Period
Delay
Resolution
Accuracy
Modes
Trigger</td><td colspan="3">1000
50µSec to 60 Sec
25µSec to 60 Sec
10µSec
1% ± 10µSec
Single burst or continuous
System Trigger</td></tr>
<tr><td>Rise and fall time 10% - 90% of max range</td><td>Range
Accuracy
Resolution</td><td colspan="3">10µSec to 60 Sec
1% ± 10µSec
<10µSec</td></tr>
</table>

CC, CV, CP and CR accuracies are steady state with regulation enabled.

* CR accuracy applies when voltage is greater than 10% of range and current is greater than 10% of range.

3.19 4350 150W Measurements

Current DC	Range Accuracy Resolution	±0.66ADC ±3ADC ±30ADC 0.05% of reading + 0.05% of range 16 Bits
Voltage DC	Range Accuracy Resolution	±30VDC ±120VDC ±600VDC 0.02% of reading + 0.04% of range 15 Bits
Waveform	Bandwidth Accuracy Sample rate Record length Trigger	Voltage DC to 500khz Current DC to 100khz Analog, 1% of range Time, 1/Sample Rate + 0.05% of reading 1MS/s 256k points System Trigger, DINs, Voltage
Power	Range Accuracy Resolution	Current range times Voltage range Current Accuracy + Voltage Accuracy 16 Bits
Resistance	Range Accuracy Resolution	0 - infinity Current Accuracy + Voltage Accuracy 16 Bits
Peak to Peak Noise	Range Bandwidth Accuracy Resolution	0 to 0.25V Peak to Peak 0 to 2.5V Peak to Peak 10hz to 20Mhz 3% of range, @ 1Mhz 16 Bits
DIN Timing	Range Accuracy Resolution	7 days 0.05% of reading ±100µSeconds 100nanoSeconds

Waveform Range and Resolution is the same as Current or Voltage being measured.

3.21 4350 300W Programmable Features

<table>
<tr><td>Constant Current</td><td>Range

Accuracy
Resolution</td><td colspan="3">0 to 0.66A
0 to 6A
0 to 60A
0.06% of set + 0.06% of range
16 Bits</td></tr>
<tr><td>Constant Voltage</td><td>Range

Accuracy
Resolution</td><td colspan="3">0 to 30V
0 to 120V
0 to 500V
0.05% of set + 0.05% of range
16 Bits</td></tr>
<tr><td>Constant Power</td><td>Range

Accuracy
Resolution</td><td colspan="3">0 to Current range times Voltage range
400W or 40W max
0.5% of set + 0.5% of range
16 Bits</td></tr>
<tr><td>Constant Resistance</td><td>Range

Accuracy</td><td colspan="3">15% to 5000% of
Voltage range divided by Current range
2% of set*</td></tr>
<tr><td>Short Circuit 60A range</td><td>Current
Resistance</td><td colspan="3">60A < Isc < 90A
38mΩ max</td></tr>
<tr><td>Slew Rate</td><td>Range
Maximum</td><td>0.66A
0.066A/µS</td><td>6A
0.6A/µS</td><td>60A
12A/µS</td></tr>
<tr><td>Macro Mode</td><td>Settings
Total Period
Delay
Resolution
Accuracy
Modes
Trigger</td><td colspan="3">1000
50µSec to 60 Sec
25µSec to 60 Sec
10µSec
1% ± 10µSec
Single burst or continuous
System Trigger</td></tr>
<tr><td>Rise and fall time 10% - 90% of max range</td><td>Range
Accuracy
Resolution</td><td colspan="3">10µSec to 60 Sec
1% ± 10µSec
<10µSec</td></tr>
</table>

CC, CV, CP and CR accuracies are steady state with regulation enabled.

* CR accuracy applies when voltage is greater than 10% of range and current is greater than 10% of range.

3.22 4350 300W Measurements

Current DC	Range Accuracy Resolution	±0.66ADC ±6ADC ±60ADC 0.05% of reading + 0.05% of range 16 Bits
Voltage DC	Range Accuracy Resolution	±30VDC ±120VDC ±600VDC 0.02% of reading + 0.04% of range 15 Bits
Waveform	Bandwidth Accuracy Sample rate Record length Trigger	Voltage DC to 500khz Current DC to 100khz Analog, 1% of range Time, 1/Sample Rate + 0.05% of reading 1MS/s 256k points System Trigger, DINs, Voltage
Power	Range Accuracy Resolution	Current range times Voltage range Current Accuracy + Voltage Accuracy 16 Bits
Resistance	Range Accuracy Resolution	0 - infinity Current Accuracy + Voltage Accuracy 16 Bits
Peak to Peak Noise	Range Bandwidth Accuracy Resolution	0 to 0.25V Peak to Peak 0 to 2.5V Peak to Peak 10hz to 20Mhz 3% of range, @ 1Mhz 16 Bits
DIN Timing	Range Accuracy Resolution	7 days 0.05% of reading ±100µSeconds 100nanoSeconds

Waveform Range and Resolution is the same as Current or Voltage being measured.

3.23 4350 600W Programmable Features

Constant Current	Range Accuracy Resolution	0 to 0.66A 0 to 12A 0 to 120A 0.06% of set + 0.06% of range 16 Bits		
Constant Voltage	Range Accuracy Resolution	0 to 30V 0 to 120V 0 to 500V 0.05% of set + 0.05% of range 16 Bits		
Constant Power	Range Accuracy Resolution	0 to Current range times Voltage range 800W or 40W max 0.5% of set + 0.5% of range 16 Bits		
Constant Resistance	Range Accuracy	15% to 5000% of Voltage range divided by Current range 2% of set*		
Short Circuit 60A range	Current Resistance	120A < Isc < 180A 38mΩ max		
Slew Rate	Range Maximum	0.66A 0.066A/µS	12A 1.2A/µS	120A 24A/µS
Macro Mode	Settings Total Period Delay Resolution Accuracy Modes Trigger	1000 50µSec to 60 Sec 25µSec to 60 Sec 10µSec 1% ± 10µSec Single burst or continuous System Trigger		
Rise and fall time 10% - 90% of max range	Range Accuracy Resolution	10µSec to 60 Sec 1% ± 10µSec <10µSec		

CC, CV, CP and CR accuracies are steady state with regulation enabled.

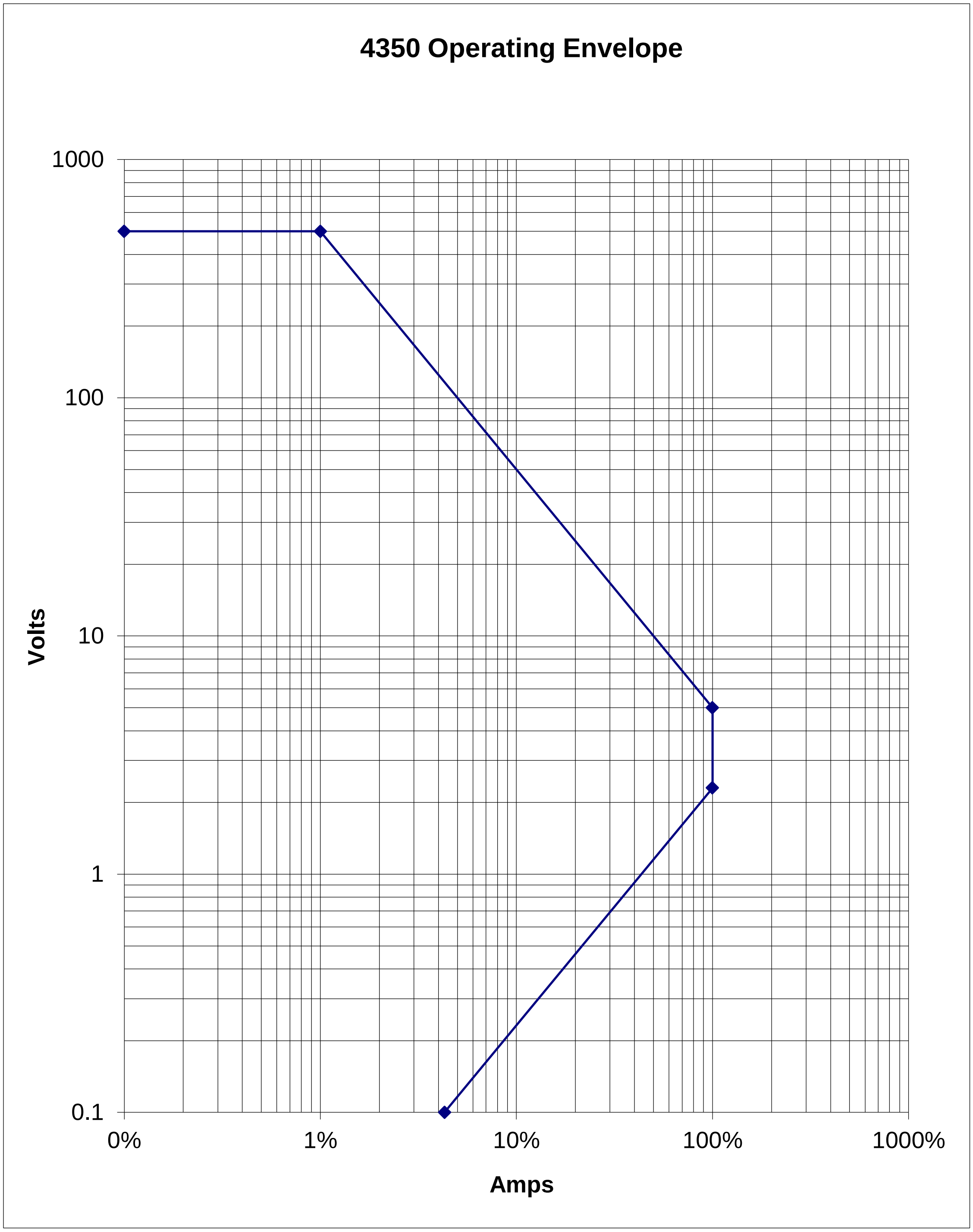
* CR accuracy applies when voltage is greater than 10% of range and current is greater than 10% of range.

3.24 4350 600W Measurements

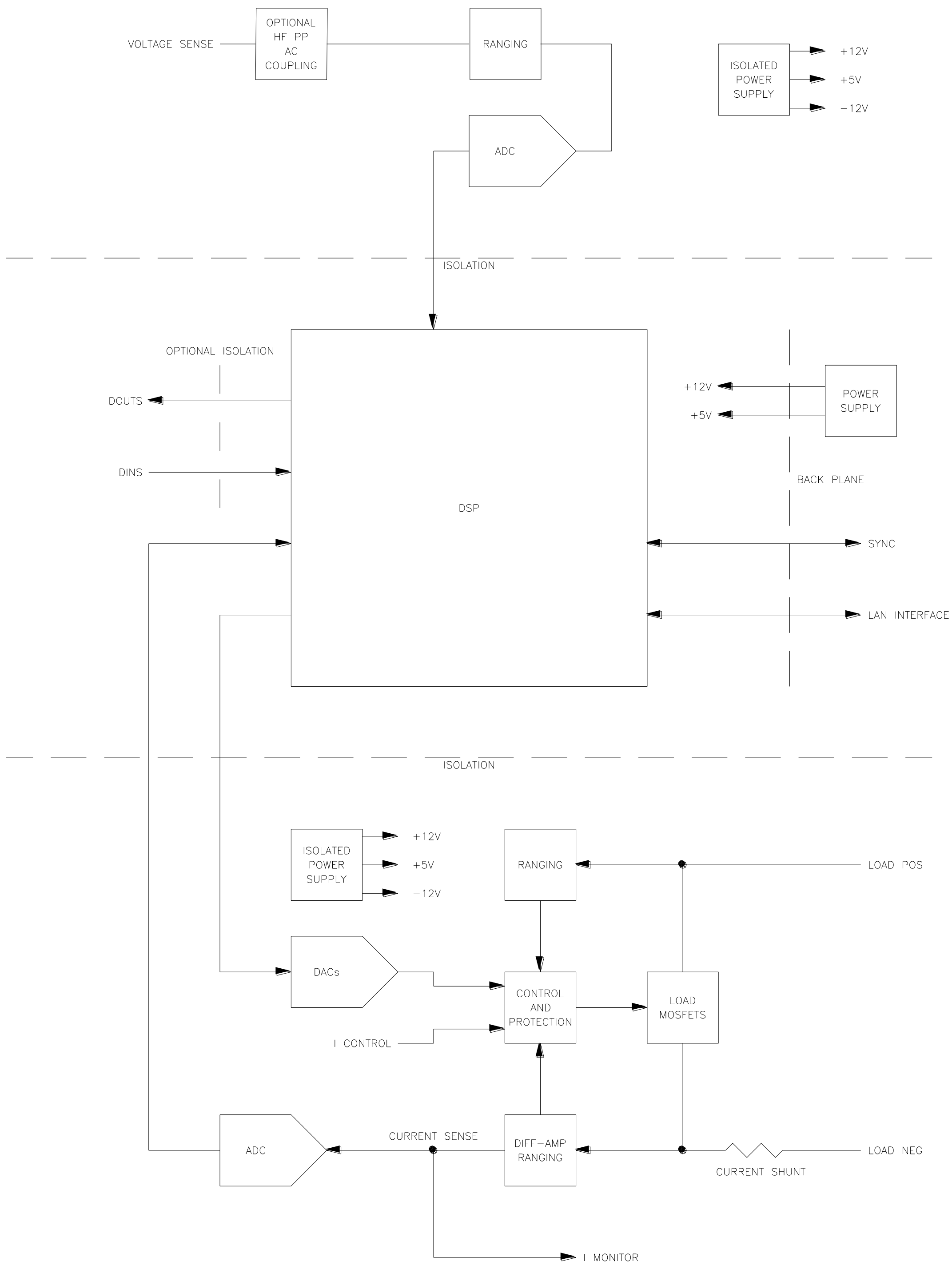
Current DC	Range Accuracy Resolution	±0.66ADC ±12ADC ±120ADC 0.05% of reading + 0.05% of range 16 Bits
Voltage DC	Range Accuracy Resolution	±30VDC ±120VDC ±600VDC 0.02% of reading + 0.04% of range 15 Bits
Waveform	Bandwidth Accuracy Sample rate Record length Trigger	Voltage DC to 500khz Current DC to 100khz Analog, 1% of range Time, 1/Sample Rate + 0.05% of reading 1MS/s 256k points System Trigger, DINs, Voltage
Power	Range Accuracy Resolution	Current range times Voltage range Current Accuracy + Voltage Accuracy 16 Bits
Resistance	Range Accuracy Resolution	0 - infinity Current Accuracy + Voltage Accuracy 16 Bits
Peak to Peak Noise	Range Bandwidth Accuracy Resolution	0 to 0.25V Peak to Peak 0 to 2.5V Peak to Peak 10hz to 20Mhz 3% of range, @ 1Mhz 16 Bits
DIN Timing	Range Accuracy Resolution	7 days 0.05% of reading ±100µSeconds 100nanoSeconds

Waveform Range and Resolution is the same as Current or Voltage being measured.

3.25 4350 Operating Envelope



3.27 Block Diagram



4300 Block Diagram

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4. INSTALLATION

4.1 Hardware Installation

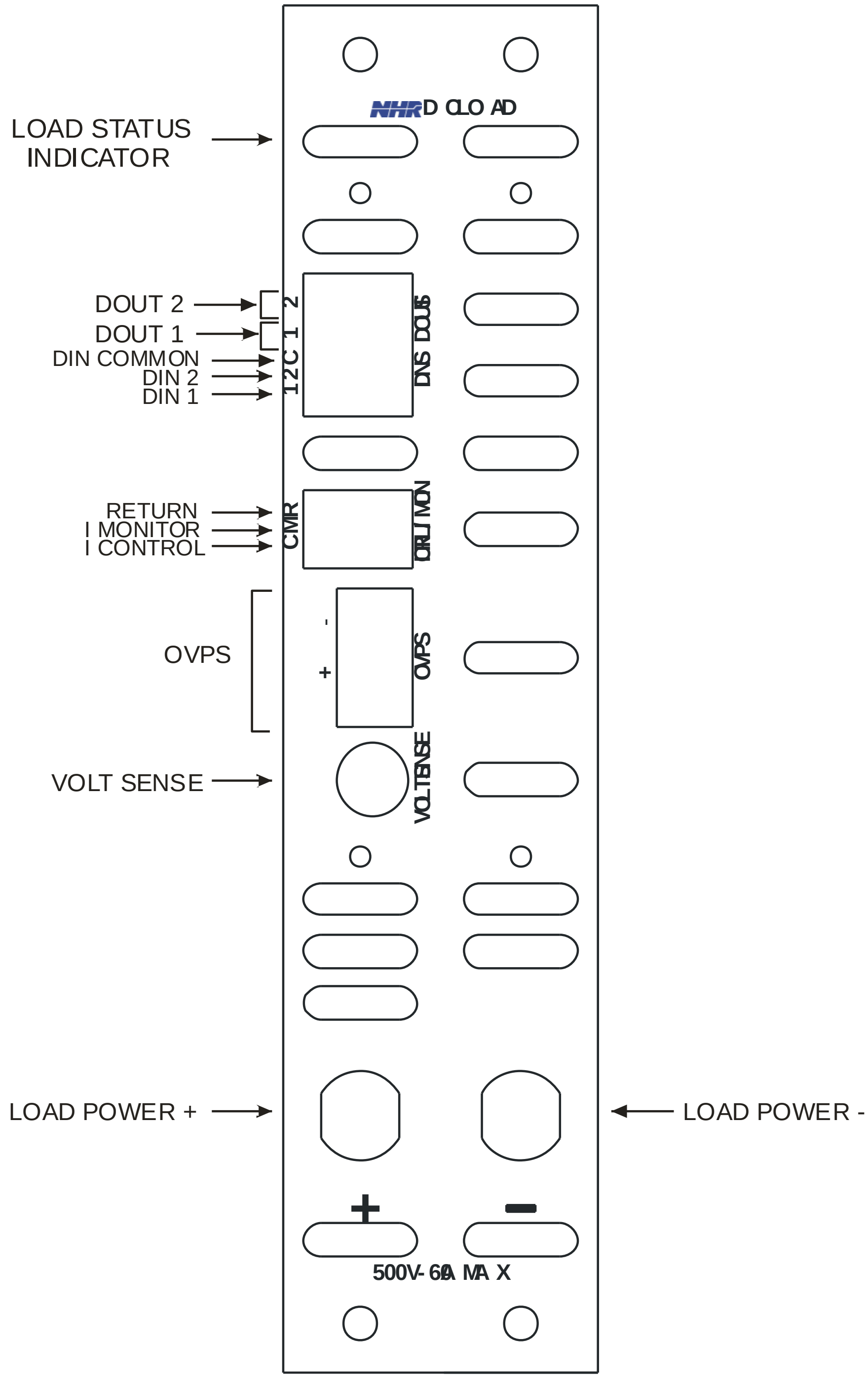
Unpack the load and or chassis. Save the packing material if a need arises to return the load and or chassis. DC Loads may be added or removed from the front of the chassis. The control board only installs in the far right slot.

4.2 Airflow

The loads will dissipate over 2.4KW of heat per chassis.

Allow for 300CFM, per chassis, of air to enter the front and exit the rear of the load. This must be fresh cool air and not hot re-circulated air.

4.3 Load Front View



LOAD FRONT VIEW

4.4 DOUTS Terminal Block in front

Each load has 2 individually isolated solid state relay DOUT's are provided for general-purpose output on the front. DOUT's are rated for ±100VDC, 300mA. DOUT 1 is on the two pins labeled 1 and DOUT 2 is on the two pins labeled 2.

DOUT's are isolated from the load and chassis up to ±600VDC. DOUT's are isolated from each other and DIN's up to ±120VDC.

4.5 DINS Terminal Block

2 logic level DIN's are provided for general-purpose input. The state may be measured. Timing measurements may be made from System Trigger to DIN's or any waveform measurement. The threshold voltage may be programmed by changing a socketed resistor, contact the factory for more information.

DIN1 input is on 1, DIN2 input is on 2. Both Dins have a common reference pin C. DIN's are isolated from the load and chassis up to ±600VDC. DIN's are isolated from DOUT's up to ±120VDC.

4.6 ICTRL/IMON Terminal Block

4.6.1 I Control

When External Current Control Enable is ENABLED, the External Constant Current set point is set proportional to the voltage on this terminal block input pin C (current control input) referenced to pin R (return). Pin R is the load input negative.

There are many programmable set points for the 4300 load. The most modes are controlled by the computer interface port. External Constant Current is controlled by the External Current Control Enable input and the Ext Current Control Voltage Input. Of ALL the enabled modes, the one that is most restrictive to current flow will prevail.

0V = 0A
10V = 100%A of the current range.
NOTE: The voltage input must be common with the load input negative.

4.6.2 I Monitor

This output voltage is a voltage proportional to the amount of current through the load on this terminal block pin M (current monitor output) referenced to pin R (return). Pin R is the load input negative.

0V = 0A
10V = 100%A of the current range.
NOTE: The voltage output is common with the load input negative.

4.7 OVPS

An Over Voltage Power Supply may be connected. A relay in the load will connect the OVPS to the load for over voltage testing. 5A fuses limit input current.

The Over Voltage positive input is on this connector pin +. The Over Voltage negative input is on this connector pin -.

OVPS Mating Connector

N.H. P/N	DESCRIPTION	QTY	COMMERCIAL PART NUMBER	MANUFACTURER.
6302294	CONN,M-N-L,3P PLUG 4.14MM CTRS	1	172166-1	TYCO ELECTRONICS CORP
6302311	CONN, M-N-L, CONTACT FEM22-18AWG	2	1-770988-0	TYCO ELECTRONICS CORP

4.8 VOLT SENSE

The voltage sense wires must be connected to the UUT’s output terminals for any modes which use voltage to operate. Voltage measurements are made from this input. The voltage sense positive is the center conductor. The voltage sense negative is the shield.

COAX Mating Connector

N.H. P/N	DESCRIPTION	QTY	COMMERCIAL PART NUMBER	MANUFACTURER.
6000262	CONN, COAX MINIATURE SMB	1	131-1403-016	JOHNSON

4.9 Load Power

Input power positive is applied to the load on this large connector pin +. Input power negative is applied to the load on this large connector pin -.

4.10 POWER Switch

Turns chassis power on/off.

5. OPERATION

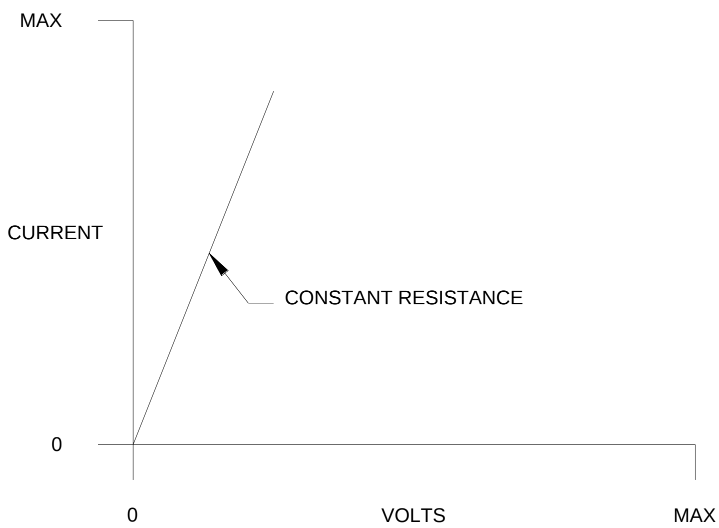
5.1 Load Status Indicator

This indicator is located in the front at the top of the load. This LED blinks at a one hertz rate during normal operation. If the LED is not blinking, remains off or on, the DSP is not operating. Green indicates normal operation, no errors. Yellow indicates an error has occurred yet the load is still operating. Red indicates an error has occurred and the load has shut down.

5.2 Operating Modes

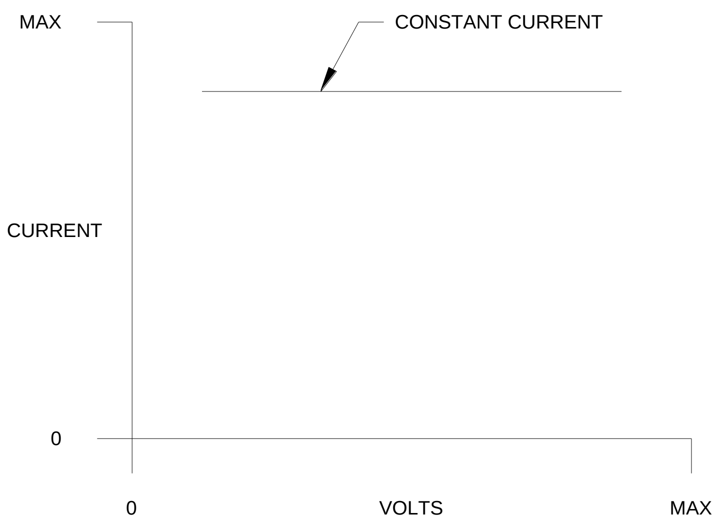
5.2.1 Constant Resistance

In this mode, the load will draw current proportional to voltage as programmed by the resistance.



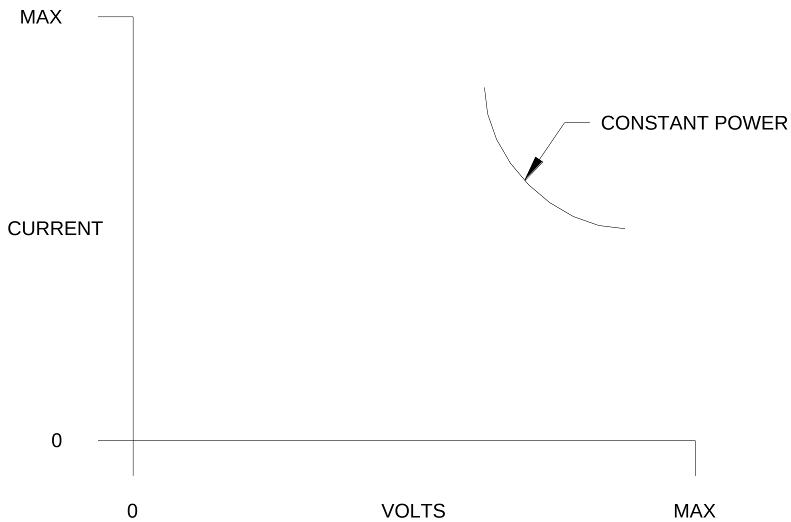
5.2.2 Constant Current

In this mode, the load will draw the current programmed without regard to voltage.



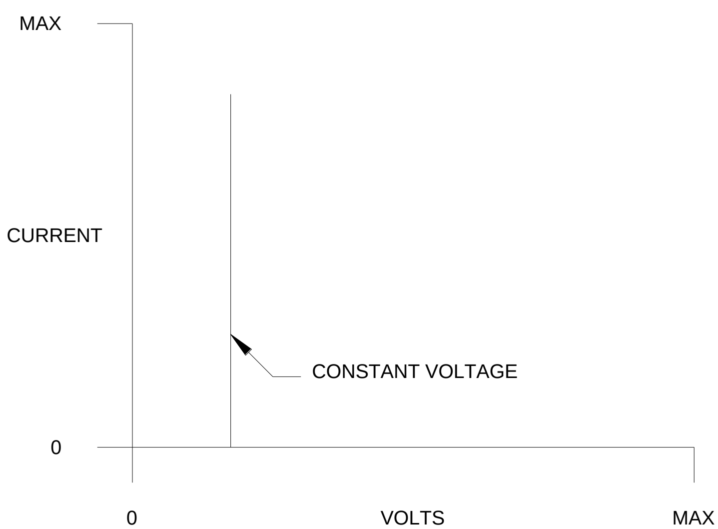
5.2.3 Constant Power

In this mode, the load will draw the current required to maintain the programmed power.



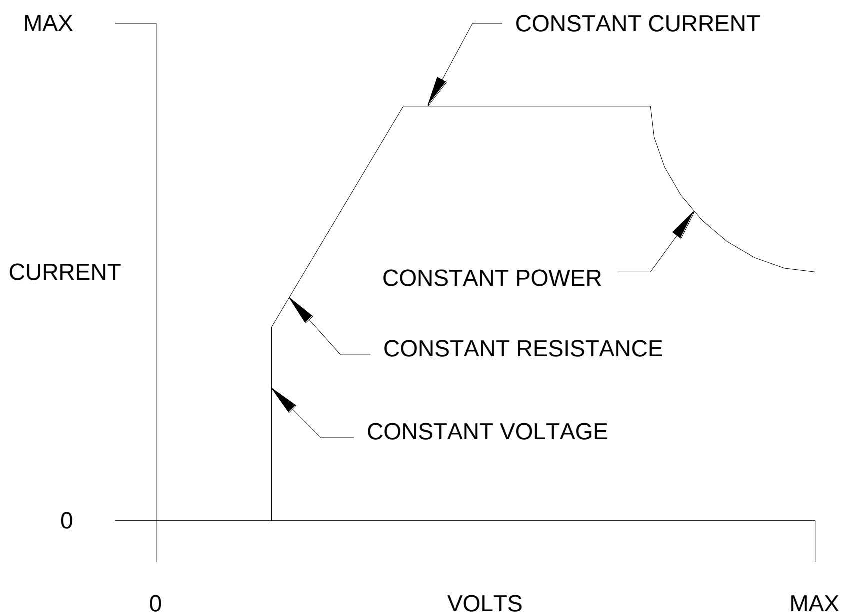
5.2.4 Constant Voltage

In this mode, the load will draw the current required to maintain the programmed voltage.



5.2.5 Auto Mode

When more than one mode is enabled the unit auto switches between the enabled modes, depending on the applied input voltage. This allows smooth, automatic switching between operating modes driven only by the input voltage. To understand this operation, refer to the following drawing:



Each setting (voltage, resistance, current, or power) sets a maximum that the load cannot exceed. However, the load may be operating at a *lower* setting if the input voltage puts it in some other mode. Basically, the mode that draws the least current is in control.

For example, starting from 0V, the load current will stay at 0A until the voltage is increased to the Constant Voltage setting. As the voltage continues to increase, the load goes into Constant Resistance Mode. As the input voltage rises further, up the load will go into Constant Current Mode. As the input voltage is raised further, the load will go into Constant Power Mode. Finally, if the input voltage is raised above the maximum rated voltage, the load will draw current to limit voltage.

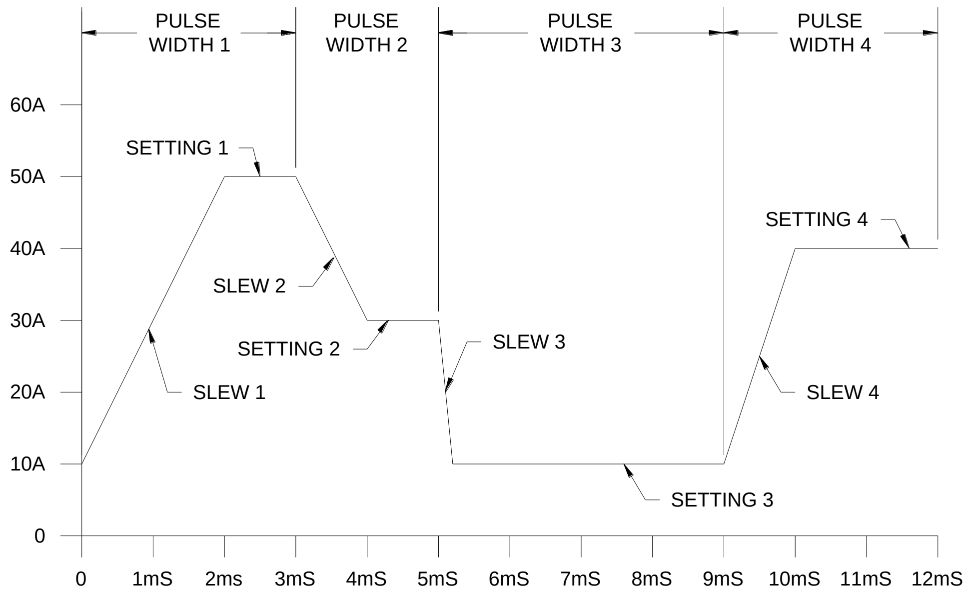
Note that not all of these modes may actually be used, depending on the settings and if they are enabled. For example, if the Resistance setting is too small, or the Voltage setting too large, the load will go directly from Voltage to Current Mode. Alternatively, if the Resistance is high enough and the Power is low enough, the load may go directly from Resistance to Power Mode.

The Voltage Mode may also be used as a programmable under voltage turn off. See the discussion under "Under Voltage" below for more information.

5.2.6 Macro Mode

Macros may be executed in (current, resistance, power or voltage) modes. Other modes may also be enabled to form auto mode during a macro.

In macro mode, the load puts out a sequence of up to 1000 programmable settings. The time delay between each new setting is independently programmable. This feature, along with the programmable slew rate, allows the user to synthesize a wide range of multi-leveled square, pulse, ramp, or triangle waveforms. The output sequence may be synchronized to other modules for parallel operation. Macros may run a single burst or continuous.



This current waveform is programmed as follows:

Constant current mode is selected at 10A.

Step 1, set pulse width to 3mS, slew rate to 20A/mS (40A/2mS) and current to 50A.

Step 2, set pulse width to 2mS, slew rate to 20A/mS (20A/1mS) and current to 30A.

Step 3, set pulse width to 4mS, slew rate to 200A/mS (20A/0.1mS) and current to 10A.

Step 4, set pulse width to 3mS, slew rate to 30A/mS (30A/1mS) and current to 40A.

5.2.7 Short Mode

In short mode and the highest current range, all FETs are saturated on. Current will limit from 100% to 150% of range. Measured current over 100% may return invalid.

5.3 Slew Rate

Programmable slew rate may be independently programmed for (current, resistance, power or voltage) modes. A slew rate (with a time step greater than 20μS) is implemented digitally with a DSP processor, giving high accuracy and flexibility over a wide range without any calibration.

The default slew rate “0” is not the fastest. The load will slew faster if programmed to a larger slew rate. See Programmable Features for default and maximum slew rates. Due to inductance in a fixture, fast slew rates may cause large voltage transients.

5.4 Dynamic Performance

The load is turned off when changing operating ranges, to avoid transients. The user selects an operating range explicitly via a range select command at the beginning of each test. The load does not change ranges under any other conditions, to avoid glitching.

5.5 Under Voltage

If the voltage decreases below minimum operating value, current will also decrease to prevent the load from going into a fully on state at 0V. Constant voltage can be set which will turn the load completely off below this voltage. Thus, the exact turn on behavior is fully programmable without any special operating modes.

5.6 External Modulation

The current can be modulated with an external analog signal. This signal is referenced to the output common (the low side), and not isolated. The external modulation is controlled by an enable bit that can be set by a software command.

5.7 Current Monitor

The output current can be monitored. This signal is referenced to the load negative input.

5.8 Digital Input

Two external logic level DIN is provided. The state may be measured. Timing measurements may be made from Trigger In to Digital In or any DSO measurement. This signal is referenced to the load negative input.

5.9 Trigger Input

The load includes a trigger input to synchronize a programmed load set step with external devices. The trigger input is available from the chassis and not directly from the load. This may be turned on or off under software control.

5.10 Trigger Output

The load includes a trigger output synchronized to a programmed set step, for triggering external measurement devices, such as an oscilloscope. The trigger output is available from the chassis and not directly from the load. This may be turned on or off under software control.

5.11 OVPS Relay

For compatibility with NH Research Powertest® automated power supply test systems, a DPST relay is included on the load to connect the UUT input leads to an external OVPS. The relay contacts are rated for 5A maximum.

5.12 Parallel Loads

Loads can be paralleled in all operating modes, including Short Circuit Mode. Loads can be software configured into logical loads. Load changes are synchronized via the back plane and the on-board DSP processor. No special hardware connections are necessary for synchronization or current sharing.

5.13 Metering

5.13.1 Remote Voltage Sense Input

Remote voltage sense input lines are provided to avoid errors in voltage measurements due to drops in the main output cables. These sense lines must always be properly connected.

5.13.2 DC Measurements

DC average measurements include voltage, current, power and resistance.

5.13.3 DSO and Timing Measurements

Sampling Analog to Digital Converters are used for metering which allows the display of waveforms similar to a Digital Storage Oscilloscope.

The following measurements are available for Voltage and Current: Overshoot, Undershoot, Rise Time, Fall Time, Settling Time, Hold Up Time, AC RMS, AC+DC RMS, Trigger In Time, DIN State and Time.

5.14 Protection Circuits

5.14.1 Over Current

In all operating modes, except short mode, current through the output FETs is limited to a maximum level slightly higher than the maximum for that range.

5.14.2 Over Voltage

If voltage greater than maximum, the load will draw current and prevent the voltage from rising. If voltage and power is exceeded, the load may be damaged.

5.14.3 Over Power

If maximum power is exceeded the current will drop to limit maximum power.

5.14.4 Over Temperature

The unit shuts down when the temperature of the heat sink exceeds a preset limit, for maximum safety and reliability.

The over temperature function protects the module from exceeding its maximum operating temperature and thus damaging itself.

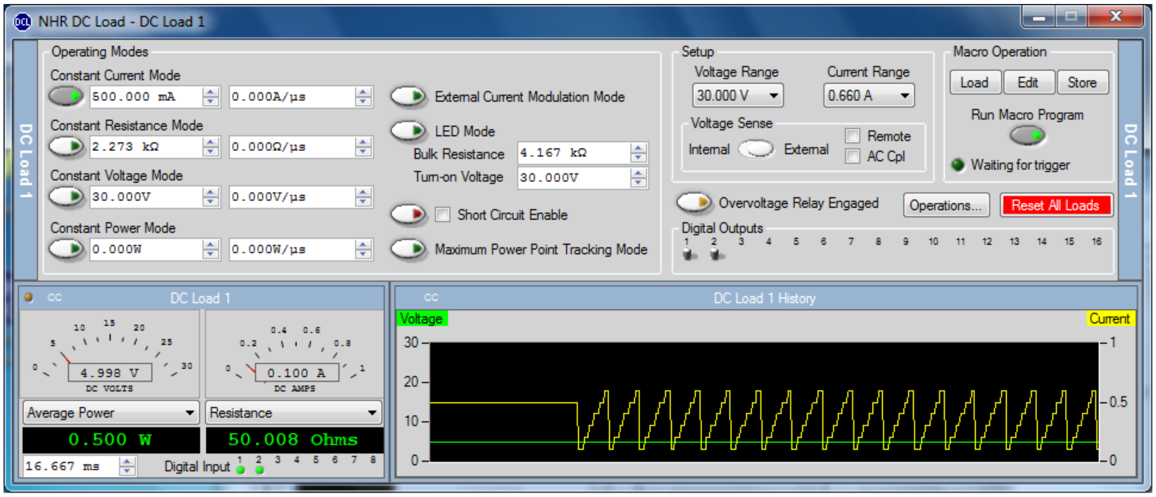
5.14.5 Reverse Voltage

Each FET has an internal reverse parallel diode to short the output in the presence of a reversed DC voltage input.

5.15 NHR IVI Instrument Panel

The NHR IVI Instrument Panel (referred to as the softpanel) can be started from the desktop icon or the start menu in the NH Research program group.

The panel should look similar to this after loading…



If there is more than one load in your configuration, the softpanel will adjust itself to maximize the number of loads visible at one time. Depending on your configuration and computer monitor, your softpanel may appear slightly different, but the operations remain the same.

Important note: Some of the modes and features presented in screen shots and text within this document may not be available with your particular load.

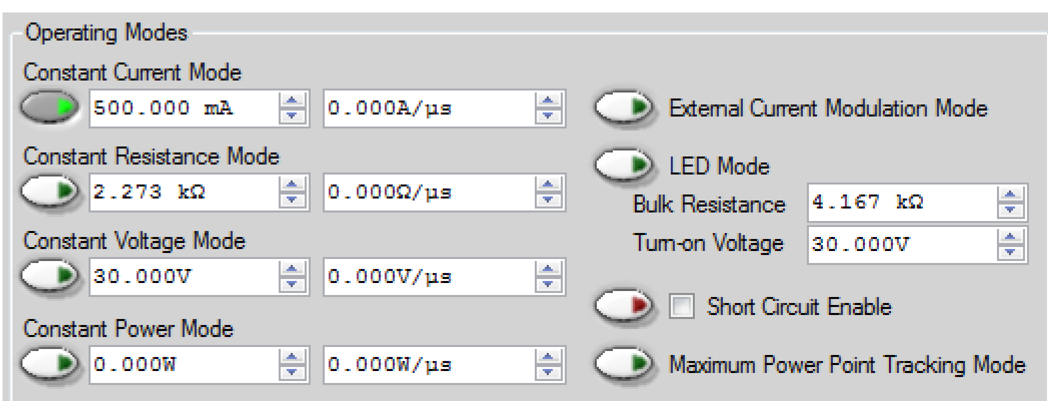
The soft panel can control many different load models, and the capabilities of each load vary from model to model. If a capability is not supported, the feature will be disabled on the soft panel.

Please refer to the Specification section to determine the capabilities of your load model.

The title bar and side bars contain the logical name of the DC Load you are currently controlling. This softpanel can control any number of physical loads, including NHR loads of different types. Use the Control section to set the various features of the selected load. To switch loads, simply click anywhere within the measurement or history window of the desired load. Switching from one load to another does NOT affect the settings. The Control section is automatically updated to reflect the state of the selected load.

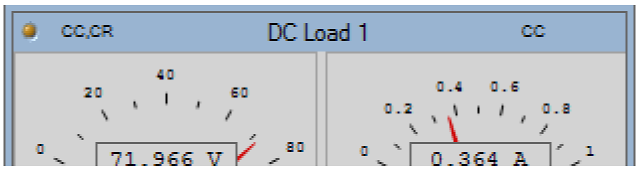
The panel allows full control of the DC load. The panel is divided into 8 sections.

5.15.1 Operating Modes Section



This is the section used to control the principal operating characteristics of the load. This load supports any number of modes enabled at a time. To enable a mode, press the corresponding switch. If all the switches are off, the load is off (high impedance). In the sample above, Constant Current mode is enabled.

The measurement section of each load contains information indicating which modes are enabled for the load, and which of the enabled modes is the active one. The text near the left-hand measurement active LED indicates which modes are enabled: CC for constant current, CR for constant resistance, etc. On the right-hand of the title bar the active mode is indicated:



Important note: 43xx loads do not support the reporting of the active mode. The right-hand area will be blank.

The active mode is the mode that is the most restrictive of the current being drawn. It is dynamic and will change based on the conditions present. For example, suppose you have a 12V 100A source hooked up to the load. The following table shows a few examples of how the various modes would interact.

Enabled Modes	Active Mode	UUT Volts	UUT Amps
CC at 50A	CC	12	50
CR at 1ohm	CR	12	12
CP at 1000W	CP	12	83.33
CV at 10V	CV	10	110
CC at 50A CR at 1ohm	CR	12	12
CC at 50A CR at 1ohm CP at 100W	CR	12	12
CC at 50A CR at 1ohm CP at 1000W CV at 10V	CR	12	12
CC at 50A CP at 1000W CV at 10V	CC	12	50
CP at 1000W CV at 10V	CP	12	83.33
CV at 10V	CV	10	105

When the External Current Modulation Mode is enabled, the load will attempt to draw a constant current proportional to the voltage on the External Current Control Voltage input. When the input is at zero volts, the load will be set to zero amps; 10 volts equals a current draw of 100% of the current range.

Short circuit mode is higher priority than the other modes. If it is enabled the load will go into short circuit mode regardless of the other modes that are enabled. Because of this, activating the short circuit mode requires two actions. First, arm the mode by checking the Short Circuit Enable checkbox. Second, click the button to the left of the enable (the one with the red LED). The short will be applied for as long as the button remains down. Click the button again to release the short circuit mode.

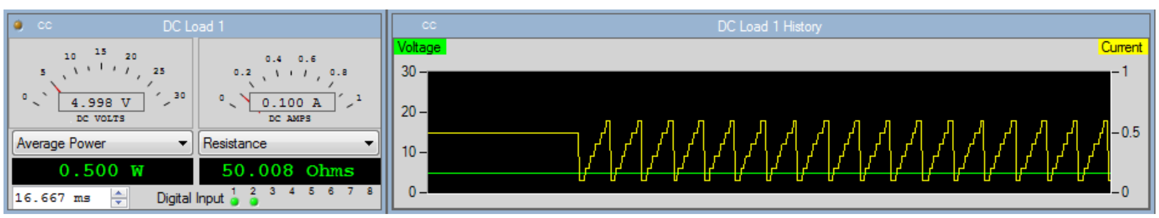
The slew rate for each mode can be set and applies only when a programmed value is changed. For example (assuming a 12V 100A UUT):

1) The load is set in CR mode at 1ohm with a 1ohm/s slew rate; the load will be drawing 12A.
2) Set the load to 2ohms. The load will decrease the current from 12A to 6A linearly over a period of one second.

When the slew rate is set to zero, the load will transition to the new state as fast as possible.

NOTE: Slew rates do NOT apply when the load is reacting to a change in the UUT.

5.15.2 Measurement Section



If enabled, the load will make measurements over a period defined by the aperture. To reduce the effect of noise, increase the aperture; to make faster, less accurate measurements, reduce the aperture. The aperture window is located in the lower-left corner of the measurement section. Each load can define its own aperture size.

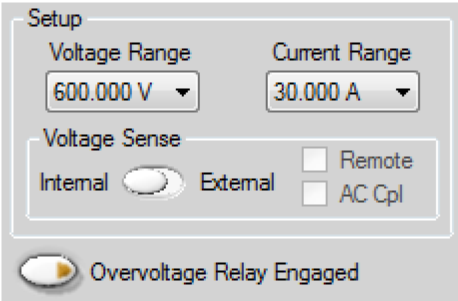
Each time a measurement is taken, the load will display the active voltage and current in the analog gauges. Two additional measurements are available in the digital gauges. Use the dropdown lists above each digital gauge controls to select the desired additional measurements.

The amber LED in the upper-left corner flashes whenever a measurement is active. You can click this light to disable the measurements. Click again to re-enable.

The measurement history chart displays the past voltage and current measurements. It is ONLY updated when measurements are active. Depending on the number of loads in your configuration, there may not be enough screen space to display the history chart all the time. In this situation, the history chart shares screen space with the measurement window and a "+" sign will be visible in the upper-right corner. Pressing the "+" button will toggle between the measurement window and the history chart.

If the load supports Digital Inputs (DINs), the state of each input is displayed via an LED. When the LED is lit, the DIN is high; when off, the DIN is low.

5.15.3 Setup Section



This section sets up the load's operating ranges and controls whether the external sense is enabled and whether the overvoltage relay is engaged.

The voltage and current ranges affect the operating range of the hardware. When either is changed, the load will go to the off state, and the settings and slew go to their default state for that range. Changing the range has the same effect as RESET.

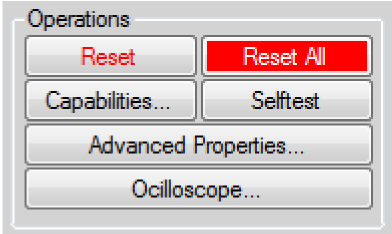
Switching voltage sense to external will cause the load to use the voltage present on the external sense connector for all metering. If external sense is selected but not connected, you will measure 0V.

Important note: Internal Sense is not available on the 43xx loads. This feature will be disabled on the softpanel. If external sense is not connected, you will measure zero volts. Please refer to the Specification section to determine the capabilities of your load model.

Some load models support AC coupling and "remote" measurements. When remote is selected, the load will disregard all voltage measurements and restrict its operating mode to constant current. This allows external voltages to be monitored by the load measurement circuitry without affecting the behavior of the load itself.

Selecting overvoltage relay engaged will activate the internal relay, which causes the overvoltage input to be connected in parallel with the load. CAUTION: This relay is only rated for 5A. If the load is drawing more than 5A, the panel will prevent you from engaging the relay. However, there is no additional protection and if you try to draw more than 5A damage to the relay may result.

5.15.4 Operations Section



5.15.4.1 Reset

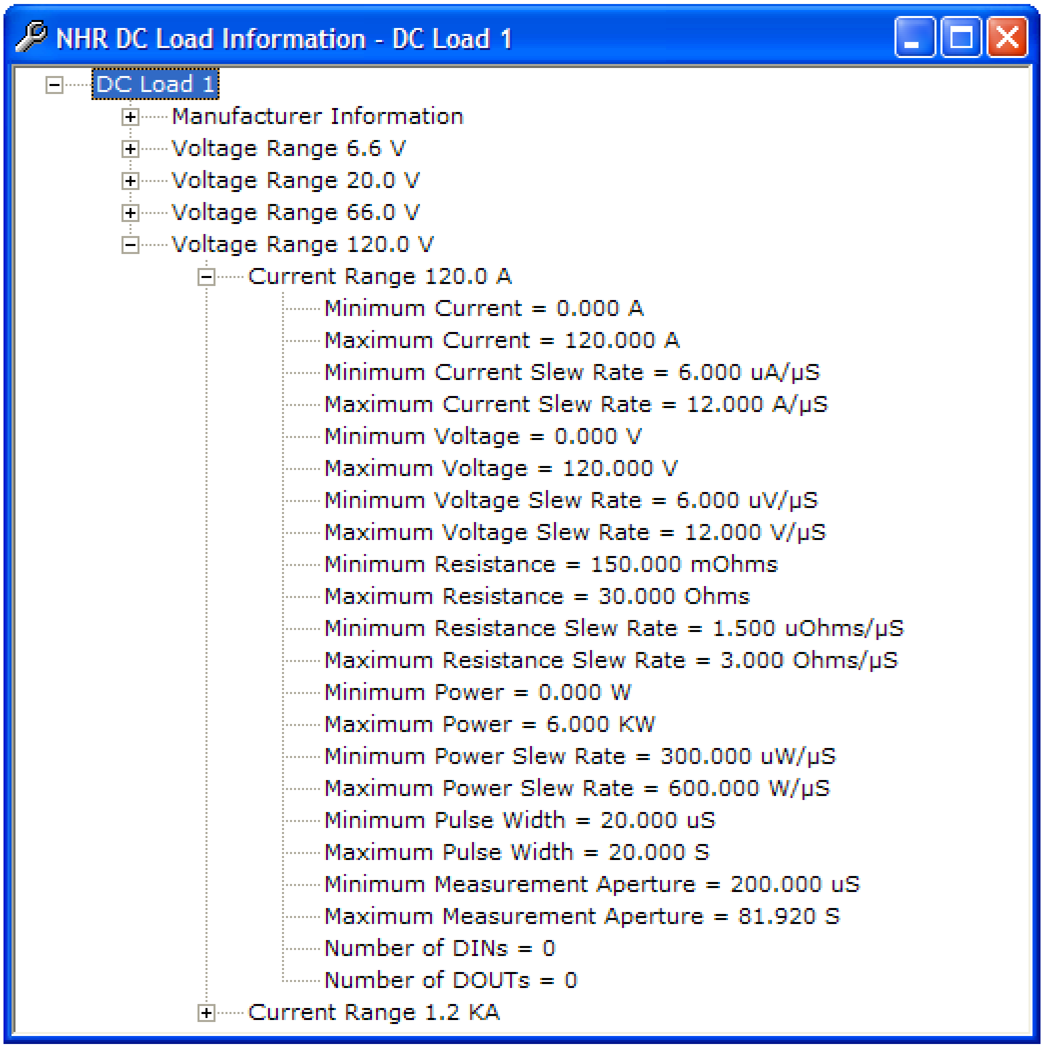
Pressing reset will reset the selected load and set all settings back to default. After reset, the load will be off.

5.15.4.2 Reset All

This button will reset all the modules in the panel to their default settings.

5.15.4.3 Capabilities

Pressing capabilities will display a dialog that allows you to see the minimum and maximum settings for all values of the selected load for any range you choose.



The Manufacturer Information section contains useful data such as the load's serial number, hardware and firmware revision numbers, and date of last calibration.

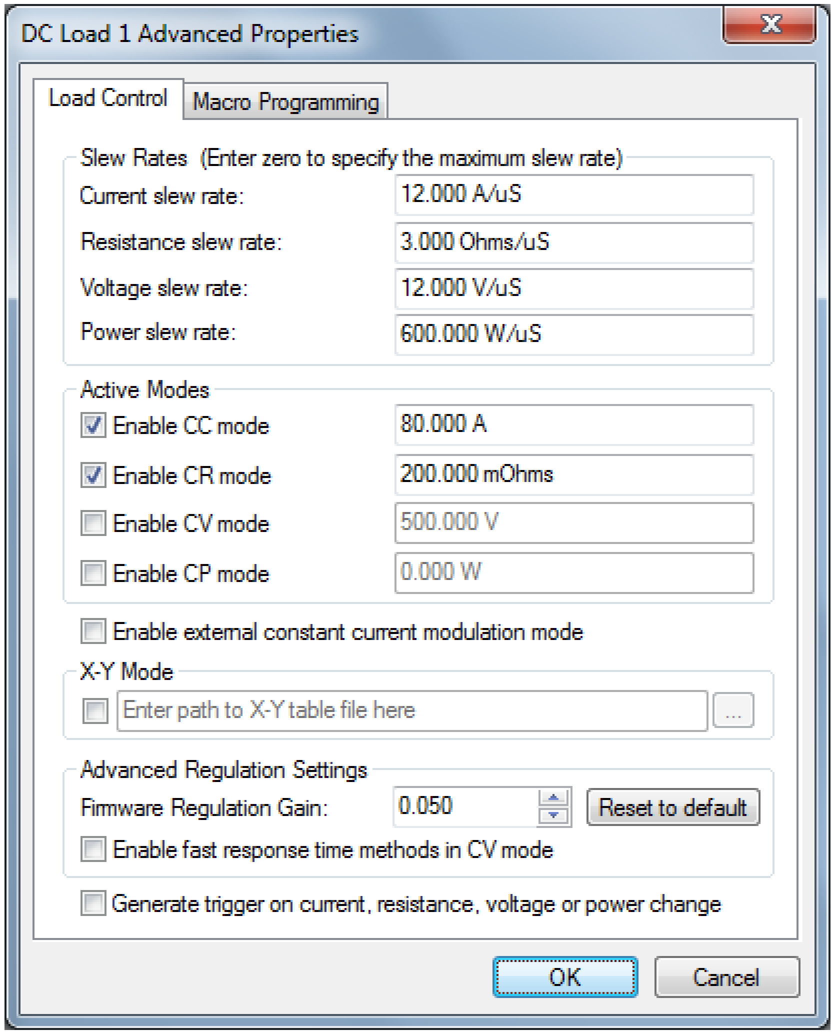
5.15.4.4 Selftest

Pressing self-test will reset the selected load then perform a built-in test. After the test is complete, a pop-up dialog appears informing the results of the test.

5.15.4.5 Advanced Properties

Pressing advanced properties will display a dialog that allows you to set properties that, while rarely used, can be beneficial when operating the load.

From the dialog below, you can see that the advanced property dialog contains fields that duplicate those found on the softpanel itself. When OK is pressed, the softpanel will refresh itself to reflect any changes made within the advanced property dialog.



If an advanced property is disabled, that feature is not available on the selected load hardware. The unique advanced properties are listed below.

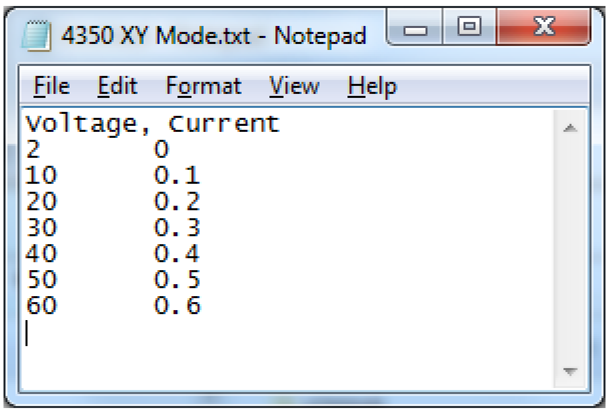
X-Y Mode

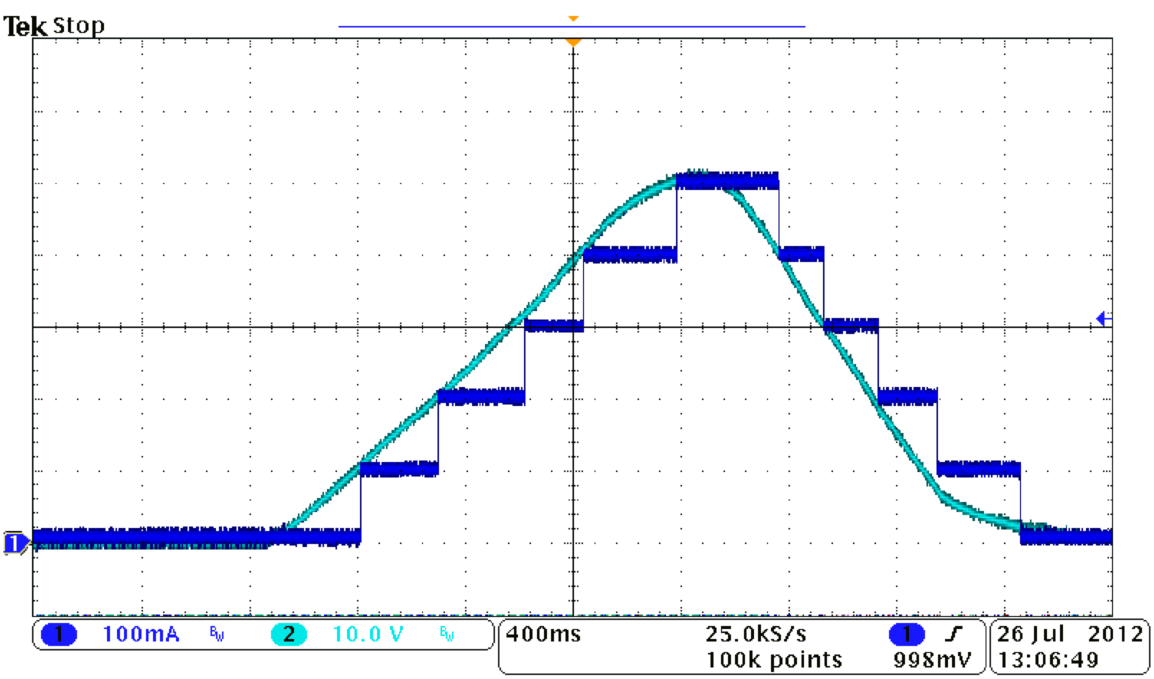
X-Y mode uses a look-up table to correlate a measurement to an output setting, allowing the load to track changes in the UUT and change its setting accordingly. Like the graph of a function f(x) = y, an input X results in an output Y. When this option is enabled, the specified X-Y table file is uploaded to the load, and the load uses the table data to set the output. The file format is an ASCII file as follows:

- The first line specifies the controlling measurement and the operating mode, separated by a comma or whitespace. The measurement can be either “Voltage” (or “V”) or “Current” (“C”). The operating mode can be “Current” (“C”), “Resistance” (“R”), “Voltage” (“V”) or “Power” (“P”). For example, “Voltage, Current” means that the load will track the UUT voltage, adjusting the Current setting as the voltage varies.
- The remaining lines contain numerical measurement and setting pairs. The first number represents the value of the controlling measurement, while the second

number represents the value of the corresponding desired setting. For example, if the controlling setup was "Voltage, Current", then "1.00, 0.5" would set the load to 500mA CC when the measured voltage transitioned above 1.0 volt. If the next line in the file read "2.00, 1.00", then the current would stay at 500mA until the measured voltage transitioned above 2.0 volts, at which time the output current would increase to 1.0 amp. The load has built-in hysteresis – if the output began decreasing, the load would remain at 1.0 amp until the measured voltage transitioned below 1.0 volts, when it would begin to draw 500mA. Note that should the actual measurement drop below the first measurement value, the load will retain the value specified in the first setting – in other words, the load will always operate within the bounds of the "settings".

You may specify up to 1000 measurement/setting pairs. The measurement values must be monotonic, and always increasing in value, but the setting values may be any value within the operating range. All the values are specified in whole units (amps, ohms, volts and watts). Here's an example:





Firmware Regulation Gain

Regulation gain is used to control the rate at which the load attempts to regulate based on the loads measurements.

This value is the percent (expressed as a decimal such that 1.00 = 100%, 0.15 = 15%, etc.) change the load will allow in each measurement sample while attempting to correct an error between the set and measured value. Setting this value higher will make faster corrections at the risk of oscillations.

For example, if the regulation gain is set to 0.30, 30% of the difference between set and measure will be done each sample. Therefore, the correction could look like this:

Programmed set = 10A CC
Sample 1: Internal set = 10.000A, measure 9.980A
Sample 2: Internal set = previous set + 0.3 * (10.000 - 9.980) = 10.006, measure 9.986A
Sample 3: Internal set = previous set + 0.3 * (10.000 - 9.986) = 10.010, measure 9.990A
Sample 4: Internal set = previous set + 0.3 * (10.000 - 9.990) = 10.013, measure 9.993A

Enable Fast Response Time Methods in CV Mode

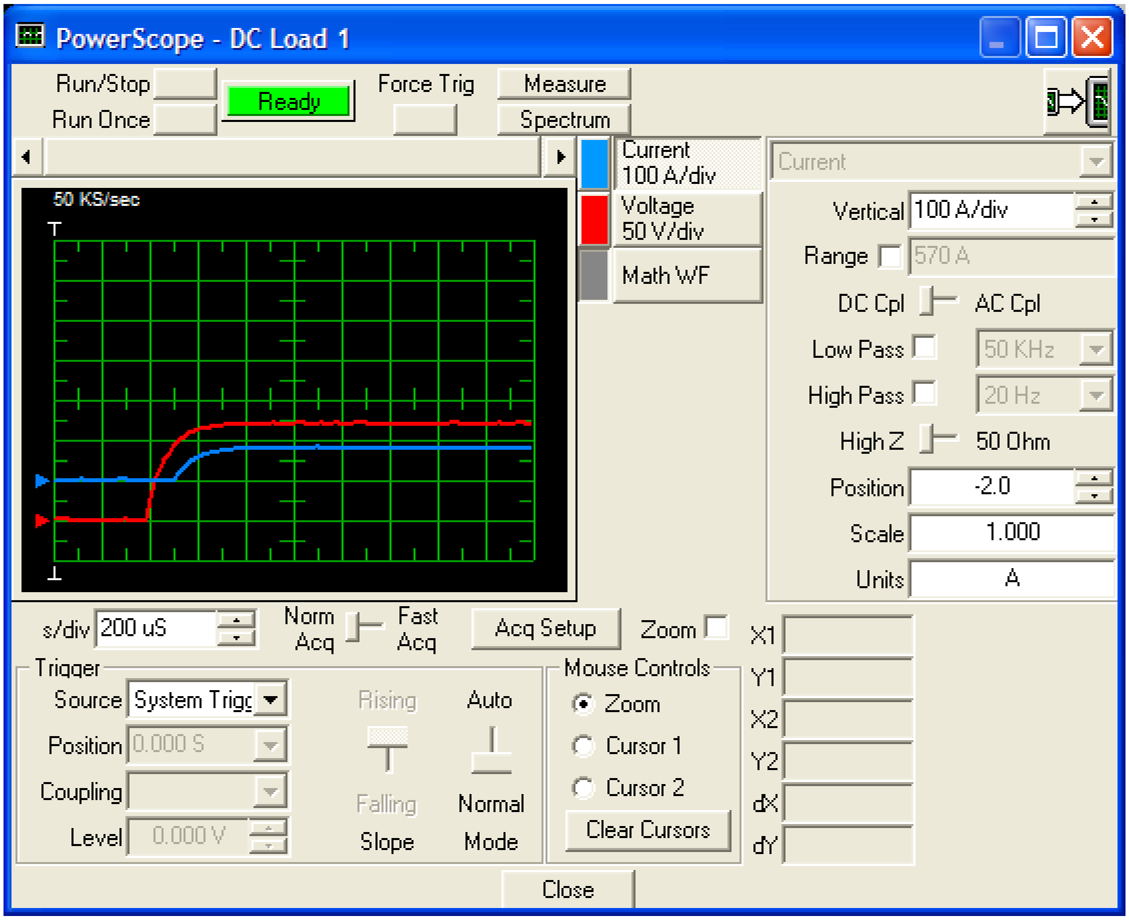
This property Controls the loop response rate of the load when constant voltage is the active mode. When enabled, the load will increase the speed at which it adjusts the voltage level. The fast loop response mode is more susceptible to oscillations.

Generate Trigger on Current, Resistance, Voltage or Power Change

When enabled, a trigger pulse will be sent on the communications line whenever a current, resistance, voltage or power value is sent to the load. Due to the design of the softpanel, this will generate a continuous trigger pulse stream when enabled. The use of this property is more practical when you are creating your own instrumentation software using the supplied instrument driver.

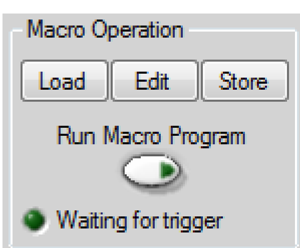
5.15.4.6 Oscilloscope

To display the oscilloscope panel for the selected load, press the Oscilloscope button. When you do, this panel is displayed.

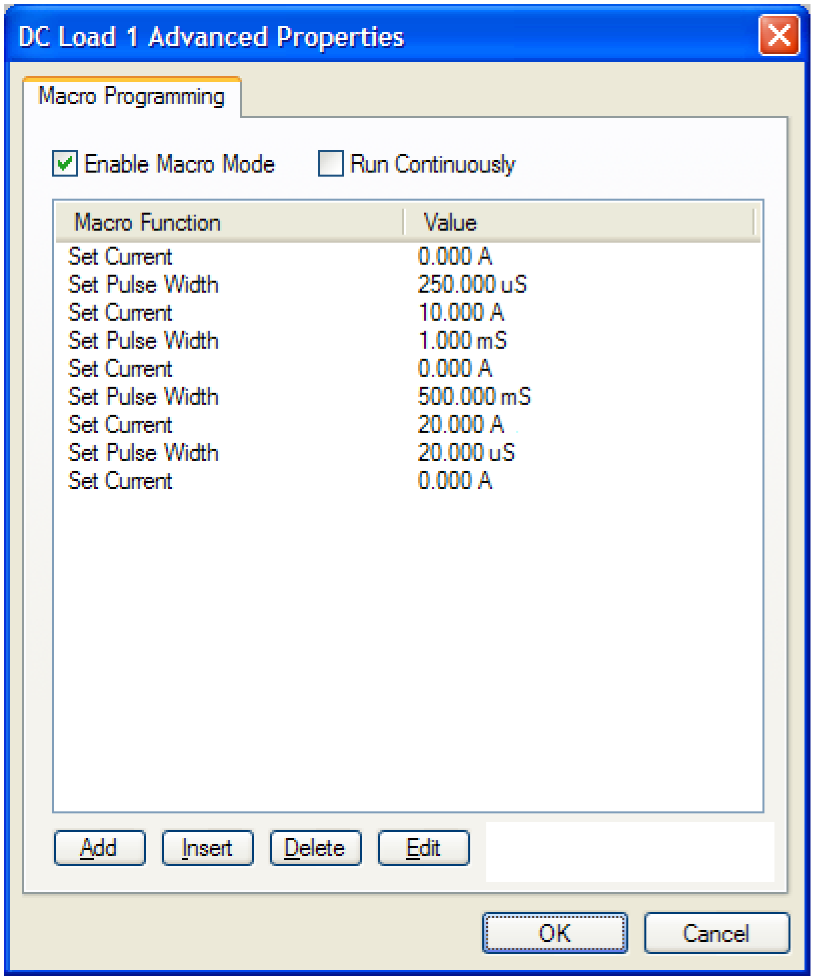


Operation of the oscilloscope panel is similar to a traditional scope. It is, however, limited to the capabilities of the load hardware.

5.15.5 Macro (Transient) Operation Section



Macro programs are sequences of load settings which can be played back to create a sophisticated pattern with precise timing. For example, if you want to create a 0 to 10A pulse 250uS wide then 1mS later a 0 to 20A pulse 500mS wide you would press the Edit button and create a sequence like this…

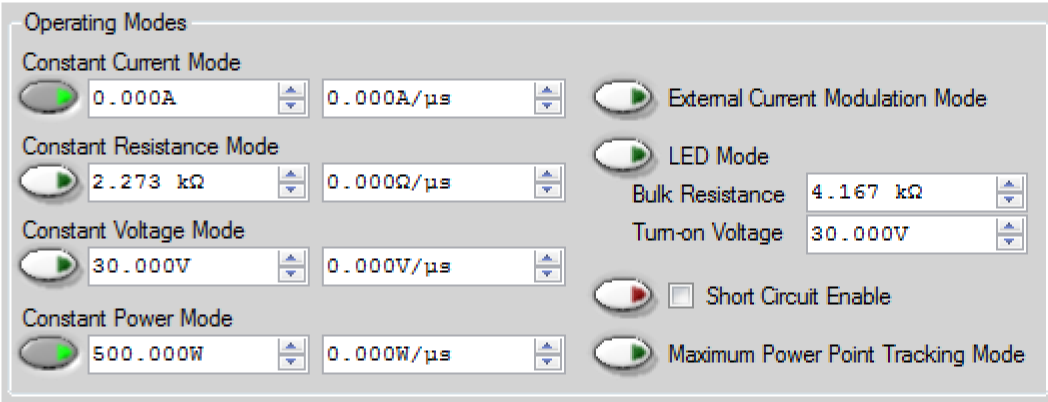


If you want the sequence to repeat continuously, check the "Run Continuously" checkbox and it will continually repeat as long as the "Run Macro Program" button is pressed. If it is not checked, the sequence will run once each time the "Run Macro Program" button is pressed.

If the macro program contains a wait for trigger command, the sequence will pause at that step and wait for a system trigger to occur. The "Waiting for trigger" LED will light and a Force Trigger button will appear so you can manually generate the trigger should the need arise.

The macro program requires the selected mode to be active in order to run. In the above example, we created a Constant Current program. If constant current mode is not enabled, a software fault will inform you that it must be enabled before the program can be run.

When running the macro program, all settings are in effect. In this example, if the settings look like this…



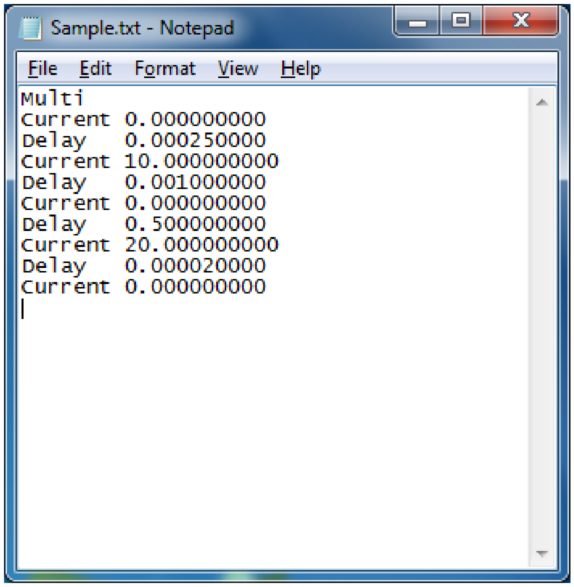
…then the maximum power will be limited to 500W regardless of the current setting in the transient program.

The Load and Store buttons allow you to save macro sequences and recall them for use at a later time. The file format is an ASCII file as follows:

- The first line indicates the active mode, and should be “Multi” (or “M”), meaning that the macro supports concurrent mode settings. (This is to retain backward compatibility with macro files created for other NHR DC loads).
- The following lines indicate the desired commands and associated values. Commands and values are separated by spaces or tabs:
    - “Current”, or “C” is the “set” value for constant current mode. It is followed by the desired current value, in amps.
    - “CSlew”, or “CS” is the rate of change for constant current values. It is followed by the desired slew value.
    - “Resistance”, or “R” is the “set” value for constant resistance mode. It is followed by the desired resistance value, in ohms.
    - “RSlew”, or “RS” is the rate of change for constant resistance values. It is followed by the desired slew value.
    - “Voltage”, or “V” is the “set” value for constant voltage mode. It is followed by the desired voltage value, in volts.
    - “VSlew”, or “VS” is the rate of change for constant voltage values. It is followed by the desired slew value.
    - “Power”, or “P” is the “set” value for constant power mode. It is followed by the desired power value, in watts.
    - “PSlew”, or “PS” is the rate of change for constant power values. It is followed by the desired slew value.
    - “Delay”, or “D” is the delay time. It is followed by the desired delay time, in seconds.

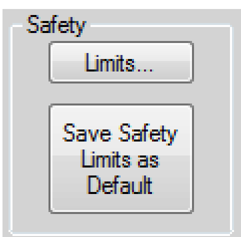
- o “Trigger”, or “T” is used to indicate that the macro should wait for a trigger before continuing execution. There is no “value” associated with a trigger.
- o “Loop”, or “L” is used to indicate the restart point for a continuously running macro. The default loop point is the first line in the macro. There is no “value” associated with the loop point.

A macro can contain up to 1000 command/value pairs. This is the sample defined above:

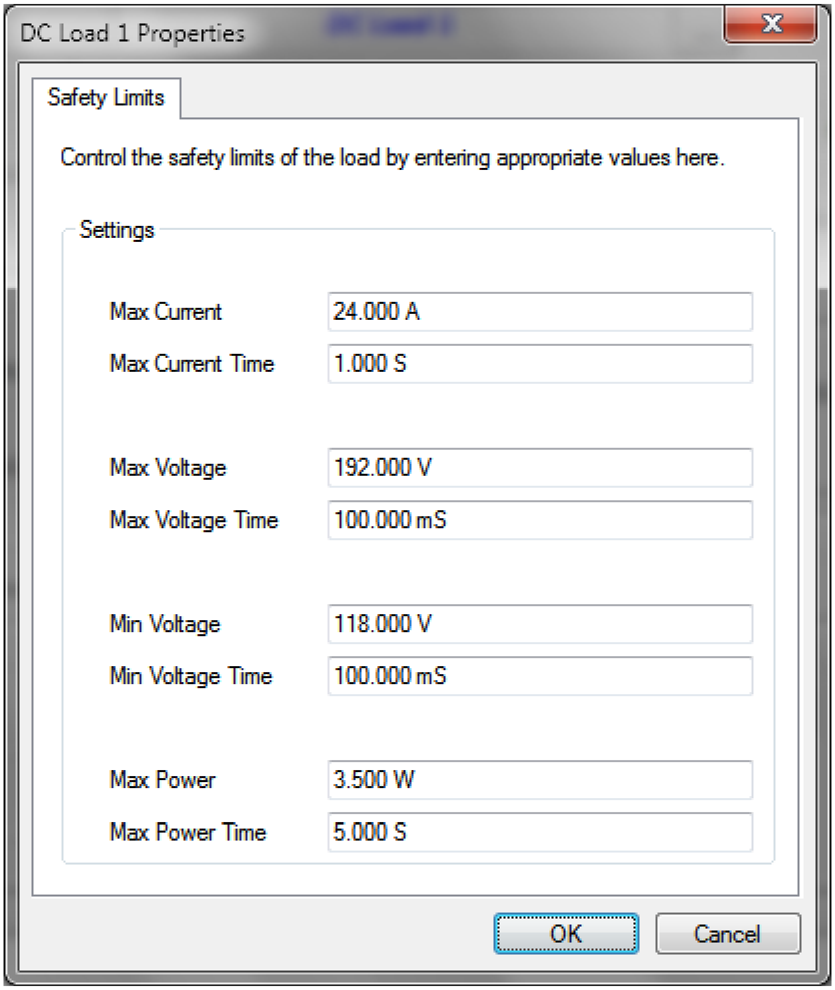


5.15.6 Safety Section

(Note: depending on your monitor resolution, this section may be part of the Operations pop-up dialog.)



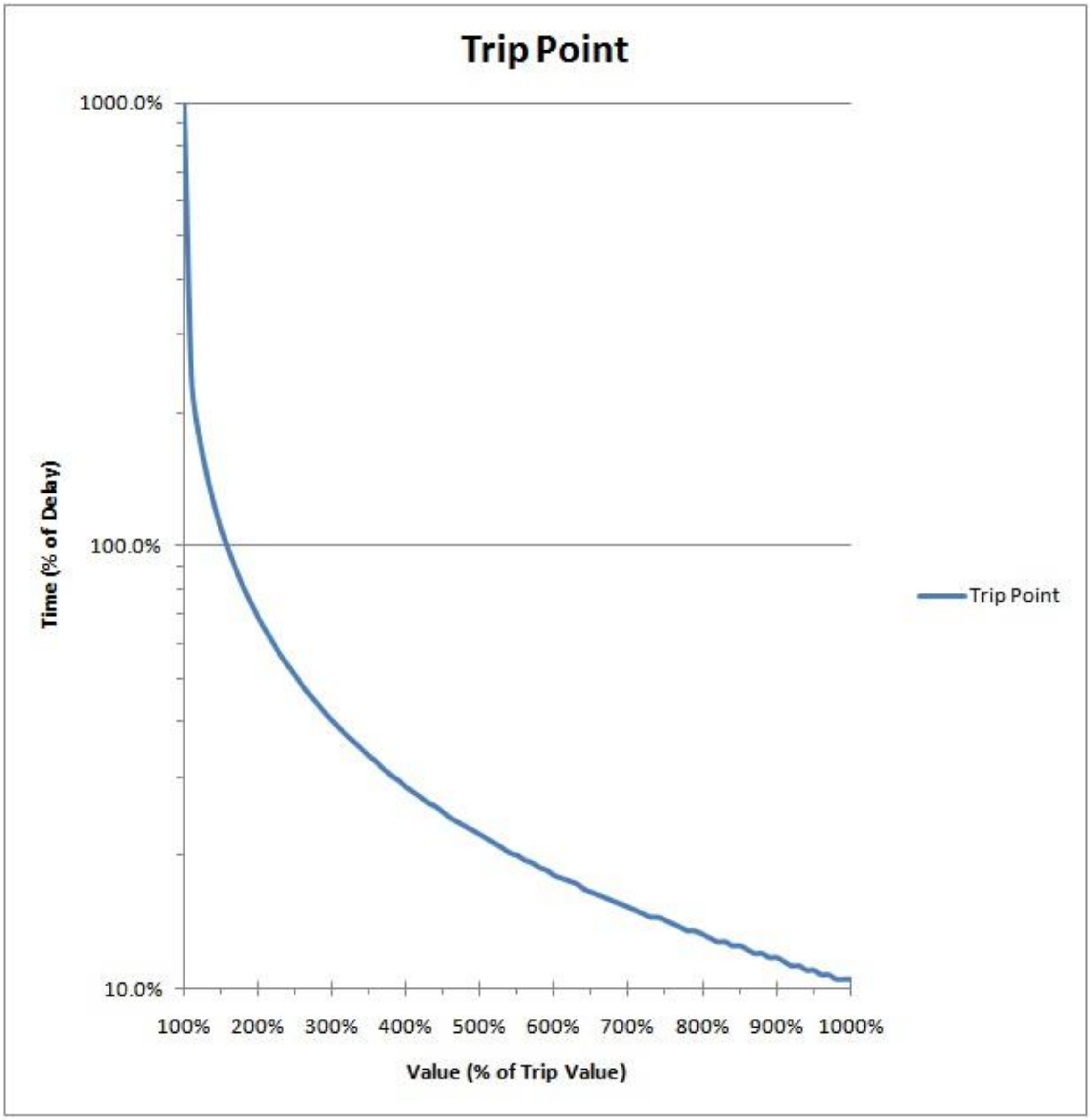
On loads that support Safety Limits, pressing the “Limits” button displays the Safety setup page:



The safety setup page allows you to set safety trip points. In essence, you are defining a "programmable circuit breaker" for current, voltage, and power. You will define a value and a time for each characteristic. Note, if you set the time value to zero, it will act as an instantaneous fuse. That is, it will trip off the instant it sees a value that exceeds the programmed setting. This often leads to false trips due to high frequency noise spikes. It is usually better to set a small (non-zero) time to avoid false trips but still provide fast trip response.

The safety trip algorithm mimics the behavior of a circuit breaker. Like a circuit breaker, the algorithm will not be affected by noise and the trip point delay will vary with the amount of overload. That is, the higher the overload, the faster the trip. The parameters that can be set are the trip value and the time value.

Here is the approximate trip point curve of the algorithm:



For example, for a 10A maximum current safety trip point and a time value of 5 seconds:

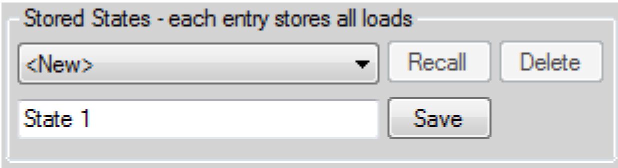
If the load draws 20A (200% of trip value) it will trip off in about 3 s (65% of time value)
If the load draws 15A (150% of trip value) it will trip off in about 5 s (100% of time value)
If the load draws 12A (120% of trip value) it will trip off in about 9 s (180% of time value)

To set the load to default to the programmed safety limits, use the "Save Safety Settings as Default" button in the "Save/Recall Settings" section.

Many NHR load models provide general-purpose Digital Outputs, useful for fixture control. The state of the digital output matches that of the corresponding toggle switch. To set the digital high, simply move the switch to its up position (as shown in #2 above); move the switch to its down position for a digital low.

5.15.7 Stored States Section

(Note: depending on your monitor resolution, this section may be part of the Operations pop-up dialog.)



As a convenience, all load settings can be saved to the hard disk for later recall. You can save as many different states as you have room on your hard drive (for all intents and purposes unlimited). All load settings are saved including the transient program. Each state stores the settings for all loads being controlled by the softpanel (one state saves all).

To save the current settings to a new state description

1. Set up all load settings as desired.
2. Select <New> in the "Stored States" selection box.
3. Modify the description if desired (the default will be "State #" which will be a unique name).
4. Press the "Save" button.

To recall a saved state

1. Select the desired state to restore in the "Stored States" selection box. In this example, "Full Load" was chosen.

2. Press the "Recall" button. ***WARNING!*** The saved state will be restored and become active immediately! If the state was stored with short circuit turned on, a short will be applied as soon as you press recall.